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ABSTRACT

This document opens with an editorial comment on two analogical models for mathematics education research. Analyses and abstracts of twelve research reports related to mathematics education follow. Four of the reports deal with aspects of learning theory, two with sex differences, and one each with achievement grouping, drill and practice, elementary teacher education, modes of instruction for measurement, teacher behavior influence on achievement, and women in education. Research related to mathematics education which was reported in CIJE and RIE between January and March 1981 is listed. (MP)

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An editorial comment . . .

The Geometry of Mathematics Education

Lars C. Jansson
University of Manitoba

Last fall, on these same pages, Kieren (1980) employed a triangle as an analogical model for mathematics education research. At about the same time an article (Higginson, 1980) appeared in the new journal For the Learning of Mathematics which employed a tetrahedral model of mathematics education. Both of these models were proposed as analogues which might assist researchers and others in the field in focussing their attention on meaningful, often multivariate, relationships.

In the remarks which follow I would like to describe briefly these models and to examine their usefulness to researchers and instructional practitioners. Clearly, for more complete accounts of the models themselves, the reader should refer to the original articles. Furthermore, the differences between the two models, as well as the overlap, may prove to be of interest. As I hope will become evident, both models already make a contribution to the understanding of our field.

Higginson argues that mathematics education is essentially multidimensional. It is commonly recognized that mathematics education brings psychology and the discipline of mathematics together. With increasing frequency it is also recognized that there is a sociological aspect to mathematics education -- a host of socio-cultural factors is meant to be included under this broad heading, including economic conditions, social structures, cultural values, technology, and language. To these three dimensions we can add a fourth, the philosophical, all too often overlooked in both research and instructional practice.

This latter facet of mathematics education activity is often overlooked because it involves the tacit assumptions we make as we go about our thinking and teaching activities. Consider assumptions concerned with the nature of "knowledge", "being", "good", "beauty", "purpose", and "value". Each of these subsets of philosophy interacts with one or more of the other dimensions described above. As Higginson points out, "Intellectual hybrids as such are

not unusual in today's academic world, accustomed as we are to physical chemistry, economic geography, sociobiology, and the like. In most cases, however, these marriages are binary, and just from the equation 'mathematics education equals psycho-philo-socio-mathematics,' we begin to get some idea why our problems of long standing have not been resolved easily" (pp. 4-5).

Higginson has proposed that these four dimensions be viewed tetrahedronally, with each discipline representing one of the faces of the tetrahedron. Certainly this structure emphasizes the interactive nature of the four aspects. The model is referred to by the author as the MAPS-Tetrahedral Model of Mathematics Education [M=Mathematics, A=Philosophy (Arbitrary?), P=Psychology, and S=Sociology]. "The fact that the tetrahedron is closed may be one way of perceiving the claim that the four foundational areas are not only necessary, but also sufficient, to determine the nature of mathematics education" (p. 5). Some tests for the efficacy of the model are also examined by Higginson.

In utilizing this model one can accentuate either its discrete or its continuous aspects. At any point in time, say t_1, there is an optimal position of point p_1 within the tetrahedron which represents the best mixture of M, A, P, and S. As new developments take place in any of the areas, at time t_2 we will have a p_2 not necessarily equal to p_1. On the one hand, one can look at the discrete, i.e., structural, aspects such as the edges MA, MS, PS, or SA, in order to look at the influence of one factor on another. For example, to the extent that the work of Piaget merges ideas from the realms of psychology, philosophy, and mathematics, his genetic epistemology can be seen as falling near the MAP vertex.

Before actually elaborating on the model discussed Kieren, it is useful to reiterate a notion employed by him to help us differentiate research in mathematics education from other areas of endeavor, such as, say, psychology, which may use mathematics subject matter. Kieren suggests that the crucial difference is the "interest center"--that all mathematics education research is concerned directly or indirectly with "the actual mathematics learning experiences of children and adults" (1980, p. iv).

Kieren develops his triangular model from the three concerns of mathematics education given by Bauersfeld: matter meant (curriculum), matter taught (teacher/instruction), and matter learnt (learner). These three concerns are

identified with the vertices of a triangle, the sides corresponding to the interactions of two of the actors, e.g., teacher-learner, or learner-curriculum. The interior of the triangle represents the interest center for mathematics education, and thus learning research in mathematics education, involving to some degree all three components, is found in this interior. Learning research involving these components but with a different interest center, e.g., psychology, is found in the exterior of the triangle.

Kieren's triangle is a model of mathematics education research foci. Higginson's tetrahedron is a model of mathematics education--but also a model for researchers. The triangle is subsumed by the tetrahedron, but precisely how is not clear. In the triangle the teacher appears as a separate component and thus relationships between the teacher (or instructional process) and the learner or the content can be accentuated. In the three-dimensional model the positions of teacher and learner are less clear, although apparently psycho-philo-socio-mathematical. Both models provide a look at mathematics education which may be helpful to the researcher in determining relationships which are worthy of investigation.

The philosophical dimension is explicit in the tetrahedral model, implicit in the triangle. The triangle's vertices are all defined in terms of "subject matter," i.e., curriculum--intended, taught, and learned. Behind each of these are the factors which influence and determine why particular content was intended, taught, or learned. It is precisely these factors and their interrelationships which the tetrahedral model attempts to elucidate.

While any good research report identifies the theoretical frame of reference for the investigation reported upon, do we give enough serious attention to the philosophical underpinnings of mathematics education? Is there sufficient, high-level discussion in journals (including IME) of mathematics education goals, of notions of what mathematics is, of rationale for practice? Do we find such articles reviewed and reacted to?

The philosophical positions we take influence not only "the actual mathematics learning experiences of children and adults," but also both the implicit and explicit frames of reference we employ to research within that interest center.

References

Higginson, W. "On the foundations of mathematics education," For the Learning of Mathematics, 1980, 1 (2), 3-7.

Kieren, T. "An editorial comment. . . Mathematics education research - A triangle," Investigations in Mathematics Education, 1980, 13, (4), iii - vi.

Summer 1981

Becher, Rhoda McShane. TEACHER BEHAVIORS RELATED TO THE MATHEMATICAL ACHIEVEMENT OF YOUNG CHILDREN. Journal of Educational Research 73: 336-340; July/August 1980.
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DuRapau, Jr., V. J., and Carry, L. Ray. INTERACTION OF GENERAL REASONING ABILITY AND PROCESSING STRATEGIES IN GEOMETRY INSTRUCTION. Journal for Research in Mathematics Education 12: 15-26; January 1981.
Abstracted by LELAND F. WEBB 16

Fennema, Elizabeth; Wolleat, Patricia L.; Pedro, Joan Daniels; and Becker, Ann DeVaney. INCREASING WOMEN'S PARTICIPATION IN MATHEMATICS: AN INTERVENTION STUDY. Journal for Research in Mathematics Education 12: 3-14; January 1981.
Abstracted by KENNETH E. VOS 20

Pigge, Fred L.; Gibney, Thomas C.; and Ginther, John L. TODAY'S ELEMENTARY SCHOOL TEACHERS ARE BETTER PREPARED IN MATHEMATICS. Arithmetic Teacher 26: 48-51; March 1979.
Abstracted by JOHN A. DOSSEY 25

Sherman, Julia. MATHEMATICS, SPATIAL VISUALIZATION AND RELATED FACTORS: CHANGES IN GIRLS AND BOYS, GRADES 8-11. Journal of Educational Psychology 72: 467-482; August 1980.
Abstracted by LINDA R. JENSEN 30

Smith, Susan R.; Szabo, Michael; and Trueblood; Cecil R. MODES OF INSTRUCTION FOR TEACHING LINEAR MEASUREMENT SKILLS. Journal of Educational Research 73: 151-154; January/February 1980.
Abstracted by ROBERT M. TODD and RICHARD T. GRAHAM 30

Vaidya, Sheila and Chansky, Norman. COGNITIVE DEVELOPMENT AND COGNITIVE STYLE AS FACTORS IN MATHEMATICAL ACHIEVEMENT. Journal of Educational Psychology 73: 326-330; June 1980.
Abstracted by MICHAEL K. DIRKS and DAVID F. ROBITAILLE 39

Webster, Raymond E. VISUAL AND AURAL SHORT-TERM MEMORY CAPACITY DEFICITS IN MATHEMATICS DISABLED STUDENTS. Journal of Educational Research 72: 277-283; May/June 1979.
Abstracted by RANDALL I. CHARLES 43

Wolleat, Patricia L.; Becker, Ann D.; Pedro, Joan D.; and Fennema, Elizabeth. SEX DIFFERENCES IN HIGH SCHOOL STUDENTS' CAUSAL ATTRIBUTIONS OF PERFORMANCE IN MATHEMATICS. Journal for Research in Mathematics Education 11: 356-366; November 1980.
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Yoshida, Hajime. EFFECTS OF DRILL PRACTICE ON APTITUDE IN THE LEARNING OF MATHEMATICS. Journal of Educational Psychology 72: 706-715; October 1980.
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Becher, Rhoda McShane. TEACHER BEHAVIORS RELATED TO THE MATHEMATICAL ACHIEVEMENT OF YOUNG CHILDREN. Journal of Educational Research 73: 336-340; July/August 1980.

Abstract and comments prepared for I.M.E. by DOYAL NELSON,
University of Alberta.

1. Purpose

To determine if teacher behaviors were related to the differences in mathematical achievement of four- and five-year-old lower socio-economic status children across two curricular intervention treatment conditions.

2. Rationale

The purposes of observational systems to study teacher behavior have been to monitor implementation of educational programs and to study the relationship between student and teacher behavior and subsequent student achievement. According to the investigator, not much has been done to combine the two purposes especially with pre-school children. The present study was a spin-off or extension of a larger investigation which set out to compare the effects of two curricular approaches on the understanding of "numerical correspondence and the recognition and maintenance of equivalences" by four- and five-year-old children of lower socio-economic status.

3. Research Design and Procedures

Eight teachers were assigned to one of two mathematical curricular approaches designed to help young children (aged 4 and 5 years) learn to make correct responses to conservation of number tasks. One approach (PT) provided children with experiences in perceptional transformations which emphasized invariance of number under various spatial rearrangements. The other provided numerical operational (NO) experiences which emphasized variance of number as the result of the operations of addition and subtraction with sets of objects. Both approaches used an "interactive instructional strategy" in which children could manipulate and be active participants in what was called "games". In both approaches there were twelve sessions (three per week) of 10 to 15 minutes each, and each teacher had four students in each of three different groups to teach. All 12 sessions for all teachers and all groups

were recorded on audiotape. The information on those tapes provided data for the study being reviewed here.

A random sample of nine lessons (one from lessons 1-4; one from lessons 5-8; and one from lessons 9-12 for each of the three groups taught) for each of the eight teachers was selected from among the collected tapes. Teaching behaviors taken from these tapes were analyzed using the Observation System of Instructional Analysis (OSIA) instrument. At the end of the 12 sessions, achievement of all children was measured using a standard conservation of number test.

Teachers scores provided by OSIA and the mean achievement of the children they taught were computed and correlation coefficients found.

4. Findings

Significant positive correlations were found between these categories of teacher behavior (OSIA) and the achievement of their students:

Category	r
Teacher requests for students to clarify substantive statements	.89
Student substantive response to teacher solicitations	.80
Teacher initiated substantive interactive strategy	.70
Teacher indirect behavior/direct behaviors (I/D) ratio	.72
Teacher I/D ratio in responding	.70
Questions/lectures ratio	.70
Reflective questions/drill questions ratio	.77
Student behaviors/teacher behaviors ratio	.70
Student I/D ratio	.84
Student I/D ratio in responding	.92

Significant negative correlations with achievement were:

Teacher direct initiation of substantive information	-.70

Teacher judgment of correctness of student response	-.70

5. Interpretations

The author claims two important and interesting educational findings for this study. First, the more active involvement of children in the learning situation (manifested by indirect teaching behaviors and substantive interactive instructional strategy) is more effective in facilitating mathematics instruction and drill. Second is the negative correlation between student achievement and the extent to which teachers tend to "correct" their students' responses.

In connection with the first finding, the author points out that "direct instruction generally has come to mean that the predominate (surely it must be predominant) teaching behavior is the "lecture". In this study "indirect instruction" would include such behaviors as teachers' requests for substantive information, teachers' requests for clarification of information, and students' substantive response behaviors which may be more characteristic of "direct instruction". Evidence has been accumulating that direct instruction is more effective in facilitating pupil achievement than indirect forms. The results of this study appear to be inconsistent with such conclusions unless what is here called "indirect instruction" contains a strong element of goal-directed teacher behavior which characterizes "direct instruction".

Assuming that the results reported here can be relied upon, then it must be that young children of low socio-economic status indeed do achieve better if taught by indirect methods, while with older children direct methods result in higher achievement. The author suggests that indirect instruction may be effective for all levels but that its effectiveness for older children is decreased if it is the only method used. In any case more instruction could be provided directly in a given time, and since the older child can handle it, the method produces better results.

In connection with the finding that there is a negative correlation between achievement and teachers' tendency to "correct" pupil responses, the author is less circumspect. "Correcting" children suggests the teacher is more interested in conveying content than teaching children. Further analysis of data did reveal that teachers who corrected childrens' responses

tended to ask more drill than reflective questions and asked children to clarify responses less often. According to the author, this conforms to the notions advanced by Piaget on the way children acquire knowledge, particularly conceptual knowledge such as was involved in this study.

Abstractor's Comments

I detest the non-word math, especially when it appears in reports of scholarly activity.

Aside from that, I found this to be a good report of what appears to have been a carefully designed and thoughtfully analyzed investigation of teaching and learning. I do get nervous when the instrument upon which the whole thing rides purports to categorize teacher behaviors which are in turn given "block busting" names such as "teacher initiated substantive interactive strategy". I find it hard enough to try to figure out what that means, let alone inquire how it is found among all those other things teachers and children are doing when teaching and learning are taking place. Assuming the instrument is capable of detecting and categorizing behaviors, then there is no reason why we can't rely on the findings as reported. The other measure, that is, pupil scores on a conservation of number test, is one we've had enough experience with in the last twenty years so we should be able to handle that.

All of us are aware of the weaknesses of a correlation study when we try to assign 'causes' for the relationships we find. It's not bad when the results are consistent with other related studies, but when they don't appear to agree the trouble starts. Becher has provided as good a discussion of the inconsistencies and the possible explanations for their appearance as can be made in a limited space. I happen to believe that young children with only a limited mastery of symbolic forms must learn largely through experiences with real objects in the real world, and in the process, as I once heard Geoffrey Matthews say, "It is not permitted to save time". (I may be paraphrasing. He might have said, "It is forbidden to save time".) So the finding that "indirect teaching" is more effective with these children tends to further substantiate that belief. In any case the last bit of evidence has not been supplied and I expect we will see more studies of the kind reported here. We need more substantial designs, but this one is not to be

too strongly condemned because there were some very good design features. Making a complete tape record of every lesson every teacher taught is one of them. (Videotape would have been even better but for some reason I concluded it must have been audiotape.) With taped material a good sampling procedure is essential. The one used here looked good to me. Finally, any honest attempt to determine the relationship that exists between teaching strategy and subsequent learning deserves our attention. And this seems to have to been an honest attempt.

Bright, George W.; Harvey, John G.; and Wheeler, Margariete Montague. ACHIEVEMENT GROUPING WITH MATHEMATICS CONCEPT AND SKILL GAMES. Journal of Educational Research 73: 265-269; May/June 1980.

Abstract and comments prepared for I.M.E. by CLYDE A. WILES, Indiana University Northwest.

1. Purpose

In the authors' words, "the study was designed to examine the differential effects of homogeneous and heterogeneous achievement grouping on mathematics learning through preinstructional concept games and postintructional skill games." The terms preinstruction, postinstruction, concept, skill and game are technical terms that relate to a research model proposed by the authors at an earlier date. The research model is intended for the systematic investigation of the cognitive effects of mathematics instructional games. The dimension of the model being investigated by this study is identified as the instructional objectives of the game. This dimension is concerned with a variety of factors including instructional level (pre-, co-, and post-instructional), instructional intent (e.g., concept learning, skill maintenance), and relative achievement level of the players.

2. Rationale

Initial investigations of the model indicated that games can be used effectively to retrain and maintain skills in some settings (chiefly multiplication) and that in these same settings increasing the verbalization among players did not seem to alter the effects. However, in grouping the players for games, no consideration was given to previous learning. Furthermore, the previous studies were concerned with post-instructional intents only. The present study attempted to take into account the previous learnings of the players and to include the instructional intent of the game as a factor.

3. Research Design and Procedures

Subjects: The subjects for this study were 164 seventh-grade students in eight classes in the same school. They were taught by two teachers, each of whom had four classes. The school is located in a Northwest Chicago suburb.

Treatments: Two classes of each teacher were randomly selected to play games associated with the probability concept of "fairness of outcomes", while the other classes dealt with ordering fractions. The fraction games were intended to be post-instructional games associated with skill building. The probability games were intended to be pre-instructional games associated with concept development.

The classes selected for fraction games were pretested on the skills to be practiced and assigned to four nearly equal levels (or strata) according to their pretest ranking within the class. Stratum I contained those students with highest pretest scores and so on. Heterogeneous groups were formed by randomly selecting one student from each stratum. Homogeneous groups were formed by three or four students from the same or adjacent strata if necessary. All assignments were random, subject to these constraints and to the constraint that approximately the same number of students were assigned to either homogeneous or heterogeneous groups. The classes selected for probability concept games were likewise tested over the probability concept of "fairness of outcomes", assigned to four strata within each class, and then assigned to either heterogeneous or homogeneous game-playing groups.

The period of the study was seven weeks. Week 1 was used for pretesting, week 2 was used for scoring pretests and assigning students to groups, weeks 3 through 6 were used for the games, and week 7 was used for post-testing. During each of weeks 3 through 6, students played the assigned games twice a week for 20 minutes at a time. The content of the games was not otherwise taught during the seven weeks.

Tests: The tests were constructed to match the concepts and skills of the games. The test for the probability concepts was the same for both pre- and post-testing, while parallel forms (achieved by randomly assigning paired or pooled items to tests) were used for the fraction ordering skills. The alpha reliabilities for the skills test were both .92, while the combined reliability for the concept test was .80.

4. Findings

Analysis was done on two questions: 1. "Did the students learn?" and 2. "Did the groupings for playing the games have any effect on the group means?" All analysis was done using the individual as the unit of analysis.

The first question was approached by the use of four t-tests of group means, i.e., Pre-test versus Post-test mean for probability-heterogeneous, probability-homogeneous, fractions-heterogeneous, and fractions-homogeneous. All of these comparisons were significant beyond the .01 level. The second question was tested by Analysis of Covariance using the pretest as the covariate. The contrasts involved treatment (homogeneous versus heterogeneous), sex, and the interaction of treatment and sex. This was done separately for the pre-instructional and post-instructional game groups. None of these contrasts was found to be significant ($F < 1$). A further descriptive analysis of gain scores for each strata was reported. While some interesting patterns were noted, no statistical tests were made of apparent differences. These data did not enter into the conclusions.

5. Interpretations

The conclusions were as follows: "...the way students are grouped to play pre-instructional, concept games and post-instructional, skill games is not critical." And, "the consistency across the variables of instructional level and mathematics content indicates it is likely that the result can be widely generalized."

The authors further noted that "this was the first known instance of learning in a pre-instructional setting in which a mathematics concept was the focus." And, "the results...provide clear evidence that pre-instructional games can be effective."

Finally, "the results of this study provide additional evidence that games can be effective in promoting mathematics learning."

Abstractor's Comments

1. The article is a model of writing style. The purpose and logic of the study are clearly stated, and the descriptions of the tests and treatments are particularly helpful.

The focus of the study is small enough to allow a thorough examination of the issue. However, it is sufficiently related to a larger matter to give it significance.

3. The mechanics of the study follow good practice, with the possible exception of the unit of analysis. In spite of the random assignment of stu-

dents to treatments, the fact that the students worked as groups and shared so much common history (particularly the homogeneous groups) violates the requirement for independence of treatments. However, for an exploratory study such as this the practice is common.

3. I wondered about the possible effects on learning of simply taking the pretests. To what extent might the observed gain scores be simply the result of "the treatment" of taking the test? The design provided no control for this.

4. I was concerned about the population used and the identification of strata. While no mention was made of ability grouping within the school, it is quite common for a school to group seventh grades into "homogeneous classes". If this were the case, then the students of Stratum I in one class would be expected to be quite different from Stratum I students in another class. I can only assume that there was no systematic grouping for classes in the population used for this study.

5. I was disappointed with the treatment of data for the four strata. Of course, if the Strata I students of one class were not comparable to those of another, and so on, then casual treatment of this matter was in order. But even if so, there are still some interesting patterns in these data.

First, the gain scores clearly indicate that the learning measured by the tests and shown to be significant was primarily, if not entirely, due to the gains of the two lower strata. Furthermore, with only one exception, the lowest stratum (IV) accounts for twice as much gain as does Stratum III, and accounts for about one-half of the total gain. It is not surprising that the lower-achieving students had greater gain scores from the perspective of how much more there was for them to learn, but the extent of the actual differences is surprising. This is particularly true when we note that the higher two strata learned very little either for the "post-instruction skill" or for the "pre-instruction concept." These data strongly suggest that essential mastery of both the pre- and post-instructional material was already possessed by half of the students. For these students the practical effect of the games would be skill maintenance. This calls into question the meaning of the terms "pre-instructional" and "post-instructional". One might more clearly argue that both content areas were post-learning for

most of the students of the two lower strata.

This may be a problem for the basic research model being investigated. For example, the rationale for choosing "ordering of fractions" for the "post-instructional intent" was that most all of the seventh graders had been provided instruction in this skill and its related concepts. The rationale for choosing "fairness of outcomes" for pre-instructional intent was that an earlier study (not coordinated with the present study) showed that sixth graders generally had not mastered probability concepts, but that sixth graders could be taught them. This introduction of mastery learning into the discussion seems to be in conflict with "instructional intent". In this study, students typically had as much mastery of the pre-instructional content as they did of the post-instructional content. Hence, the equating of instructional level with instructional intent is confounded by the matter of actual content mastery. Are we to measure instructional level by actual measures of student achievement, or by historical opportunities to learn, or by systematic "exposure", or what? And, when we decide, how can we be sure these distinctions are both meaningful and reliable?

Secondly, the gain scores indicate that the top strata students had negative or zero gains (0 to -1%) when organized in heterogeneous groups, but positive gains (2 to 4%) when organized in homogeneous groups. This suggests that being placed in game situations with those less advanced than themselves provided no stimulation for learning measured by the tests, while being placed in a more competitive situation caused them to extend their learnings somewhat.

The usual pattern for students of Strata III and IV was that those of Stratum IV gained twice as much as those of Stratum III. However, in one case the heterogeneous grouping for the skill games (ordering fractions) produced about twice as much learning for Stratum III as for IV (22% vs. 12%). One might speculate that for this content the heterogeneous situation produced apathy and discouragement in these lower-achieving children. Had the usual pattern (3 of 4 contrasts) prevailed for this contrast as well, heterogeneous grouping would have an apparent advantage for students in the lower two strata.

One might speculate, therefore, that heterogeneous grouping may produce too severe a competitive situation for low-achieving students, an inadequate

challenge for high-achieving students, and generally salutory effects for the middle groups. This interpretation is intuitively appealing.

At any event, the collapsing of the data from all stata masked the fact that nearly all learning (both pre- and post-instruction) was done by the lower-achieving students. This collapsing also hid the patterns of differential effects of grouping for various achievement strata. Of course, all that can be said certainly is that these differences are apparent. It is unlikely that the investigators planned to test these contrasts for significance. The cell size would seem to be only about 10 students. And again the uniformity of the strata across classes is in doubt. However, it seems clear that further investigation with larger cell sizes is required before one can safely conclude that grouping arrangements make no differences for students in game situations.

These last two notes challenge the general interpretations of the study. To be more precise, it is not clear to this reviewer what real differences are indicated by the terms pre- and post-instruction as operationalized in this study. Nor is it clear that students of different learning levels (or strata) are affected either to the same extent or in the same way by these two kinds of groupings for games. It is clear that if only a erage learning strata of students like these is of interest, than the grouping will probably make no difference. It is also clear that games can be effective instructional strategies for students in some circumstances and settings. Precision as to the circumstances and settings is still lacking.

Carpenter, Thomas P.; Hiebert, James; and Moser, James M. PROBLEM STRUCTURE AND FIRST-GRADE CHILDREN'S INITIAL SOLUTION PROCESSES FOR SIMPLE ADDITION AND SUBTRACTION PROBLEMS. Journal for Research in Mathematics Education 12: 27-39; January 1981.

Abstract and comments prepared for I.M.E. by JAMES M. SHERRILL,
University of British Columbia.

1. Purpose

The two purposes were:

a) "...to determine how successful children are at solving different types of addition and subtraction problems prior to formal instruction in these operations and to identify which types of problems are most difficult for them to solve."

b) "...to characterize the strategies children use to solve problems and identify the factors that lead to the selection of different strategies."

2. Rationale

Among the approaches used in previous research to categorize verbal problems are classifying problems in terms of syntax, vocabulary level, number of words in a problem, etc., and classifying in terms of the open sentences the problems represent. The authors use a third approach "that considers the semantic characteristics of the problem." They state that their analysis "is generally consistent with other analyses based on problem structure."

Previous research has identified three classes of addition/subtraction problems: Joining/Separating, Part-Part-Whole, and Comparison. Other research cuts across the classes to categorize problems as ones with action or no action. The authors add Equalizing problems and two dimensions on all four classes, the action/static dimension and inclusion relationships.

3. Research Design and Procedures

The subjects were all 43 children in two first-grade classes of a parochial school. Each child was interviewed individually. In the interview, which lasted 10 to 15 minutes, the child solved 10 problems.

The problems were 2 Part-Part-Whole, 2 Comparison, 2 Equalizing, and 4 Joining/Separating. One addition and one subtraction problem were selected

from the Part-Part-Whole and Comparison classes; two subtraction problems were selected from the Equalizing class since it "most naturally represent[s] subtraction operations"; from the Joining/Separating class one addition problem, two joining missing addend problems, and one separating problems were selected. For each of the 10 types of problems, a verbal problem involving the appropriate action or relationship between quantities was generated. Other restrictions were placed on the problems and the actual problems appear in the article.

> Each problem was read to the children by one of two experimenters. Problems were reread as often as necessary so that remembering the given numbers or relationships was not a factor. Problems were always reread in their entirety rather than one statement at a time. A set of about 40 red and white Unifix cubes was made available to the students. Students were encouraged to solve the problem without the cubes but were told to use the cubes to help them solve the problem if they needed them or were not sure of their answer. If students were having difficulty solving a problem without cubes, they were reminded that they could use cubes to find the answer (p. 31).

The strategies used by the children were coded. If the strategy wasn't obvious, the "experimenter continued the questioning until it was clear what strategy the student was using or it was clear that no explanation was forthcoming."

As with many interview studies, tallies were made of the strategies and the data analysis consisted of describing the data with no inferential statistics.

4. Findings

"For the Joining and Part-Part-Whole problems more than 88% of the students used a correct strategy and over 80% found the correct answer." The Comparison problem was more difficult, with 23 students giving one of the given numbers as their response.

The six strategies observed for addition were: Counting all (counts all the "objects" involved using blocks, fingers, or counting mentally), Counting on from smaller number (same as Counting all except the counting starts from either the smaller number or its successor), Counting on from larger number (same as Counting on from smaller number except counting starts from the

larger number or its successor), Number fact (response is justified by student knowing some basic addition fact), Heuristic (response is generated from small set of known basic facts), and Uncodable (experimenter couldn't tell child's strategy).

The four strategies observed for subtraction were: Separating (larger quantity is represented and smaller quantity is removed from it; in abstract terms this is represented by a backward counting sequence), Separating to (same as Separating except the separating continues until the small quantity remains), Adding on (smaller quantity is represented and "objects" are added on until larger quantity is represented), and Matching (both the larger and smaller quantities are represented, matched one-to-one, and unmatched objects are counted).

There is discussion in the article concerning the circumstances under which the strategies occur.

For Joining and Part-Part-Whole addition problems, 26 students used the same strategy on both problems.

For subtraction, 23 students used a general strategy, i.e, tended to use the same strategy (e.g, Separating) for all problems. Fourteen students used a problem structure strategy, i.e., used a strategy that conforms to the logical analysis of the problem structure. Almost one-third of the students used a heuristic strategy at least once.

5. Interpretations

> A striking result is the high level of success of first-grade children in solving verbal problems. Children were successful both in modeling action or relationships implied in problems and in using other appropriate models of addition and subtraction. The fact that very few children relied exclusively on strategies that directly modeled the action in the problem illustrates that their problem-solving strategies involved some understanding of the nature of the operations.
>
> The first-grade children in this study gave very little evidence of the types of systematic errors reported in previous studies. Very few of them used the wrong operation in their solution (p. 37).

The subjects showed a variety of strategies and made use of them to solve various types of problems. "The results indicate that verbal problems may

be an appropriate context in which to introduce addition and subtraction operations."

Abstractor's Comments

First, the results of the study are of great importance to mathematics education. If similar results are found in either replications or expanded versions of the study, they could have significant impact on both the actual content of primary level mathematics programs and the re-ordering of the content.

Commendations should be given to the authors for providing and the journal editors for including in the article the actual problems used in the study.

The only questions about the article could probably be answered easily and quickly by the authors. While subjects are described, there is no mention of how they were selected. Two intact classes were used, but how were the classes selected? Why was the testing delayed until February? The authors state, "...at the time the children were tested, no formal instruction in symbolic representation of addition and subtraction had been given." My experience with grade one classes (I'm not familiar with the Wisconsin scene) makes this assumption a little difficult to believe. Though not required by the curriculum, the grade one classes with which I am familiar get experience with symbolic representation of addition very early in the school year. Also, there is no mention of kindergarten experience. Are we to assume none had attended?

There is some confusion between the success rates listed in the article and the data provided in Table 1, but since the authors list a conservative figure no difficulty arises.

DuRapau, Jr., V. J., and Carry, L. Ray. INTERACTION OF GENERAL REASONING ABILITY AND PROCESSING STRATEGIES IN GEOMETRY INSTRUCTION. Journal for Research in Mathematics Education 12: 15-26; January, 1981.

Abstract and comments prepared for I.M.E. by LELAND F. WEBB,
California State College, Bakersfield.

1. Purpose

The primary purpose was "to test for interaction between instructional treatments in point and line symmetry in Euclidean two-space using a verbal-gestalt-figural approach and a verbal-analytical-figural approach and two aptitude variables, cognition of figural transformations cognition of figural relations" (p. 18). Effects of both learning and transfer were tested. "A secondary purpose was to investigate the interaction between general reasoning and the treatment variables in their effect on transfer of mathematics learning" (p. 18).

2. Rationale

This experiment was one of a continuing number of studies in the area of the aptitude x treatment interaction (ATI) question first articulated by Cronbach (1957). A sequence of studies begun by Carry (1968) and others have studied the ATI question from various perspectives. Refinements in these studies have been made by incorporating results from previous studies and from theoretical models developed by Guilford (1967), Cattell (1971), Wittrock (1974), and Cronbach and Snow (1977).

The results of various studies have provided evidence that interactions between aptitudes and instructional treatments do exist, and that ATI research shows promise of providing a better understanding between aptitudes, curriculum content, and treatment variables and their effect on achievement. The investigators' synthesis of previous research suggested that a treatment that left much of the burden of organization and interpretation to the individual would show a steeper regression line (and thus more learning or transfer) than a treatment that gave explicit rules and procedures

ATIs were predicted for treatments involving spatial tasks. In a departure from previous studies, spatial visualization was not viewed as a single ability, but as a dichotomy between gestalt and analytic strategies of pro-

cessing spatial tasks. The gestalt strategy was interpreted as forming mental visual images of figures as organized wholes (Guilford's cognition of figural transformations (CFT category)). The analytic processing strategy was viewed as explicit trial-and-error checking of relationships (Guilford's cognition of figural relations (CFR category)).

Also, the investigation was designed with the expectation of an interaction between treatments and general reasoning, with the more fully elaborated treatment producing the less steep regression line.

3. Research Design and Procedures

Two different linear programmed instructional treatments were developed in the area of point and line symmetry. The transformational treatment (T) used isometries of the plane, and was designed to be less explicit and capitalize on the student's preferred processing strategy, in this case the gestalt strategy. The nontransformational treatment (N) tended to be more explicit and rule-oriented, and was designed to capitalize on the analytic strategy. In addition, the previous studies indicated that the T treatment might be more profitable for a student with high general reasoning ability. The T treatment empahsized the verbal-gestalt-figural approach, and the N treatment emphasized the verbal-analytic-figural approach. All hypotheses were stated for the three aptitudes in a positive direction consistent with the preferred model.

The development of the instructional treatments followed a systematic pattern. Two high school students were used to read and react to the materials for clarity and effectiveness of learning. Subsequent to this, the booklets were subjected to a readability test (ninth-grade level for the T treatment, eighth-grade level for the N treatment), and to a pilot study with 36 tenth-grade geometry students to insure that learning would take place and to test for reliability.

Class periods were 45 minutes each. The study completed in five class periods: two periods for pretesting, two for instruction, and one for administering the learning and transfer test. One hundred thirty two (primarily tenth-grade) students participated in the study. All students came from five sections of geometry taught by the same instructor and were randomly assigned to treatments. Complete data were obtained on 111 students.

The aptitude measures selected were as follows: for gestalt processing (CFT), the Purdue Spatial Visualization-Rotations test (PSVR); for analytic processing (CFR), the Paper Folding test, Vz-2 (PF); and for general reasoning the Necessary Arithmetic Operations test, R-4 (NAO).

The posttest consisted of 34 items, the first 10 constituting the learning test and the last 24 the transfer test. Multiple linear regression techniques were used to test each interaction hypothesis for the transfer test, with each aptitude variable treated separately.

4. Findings

Analysis of variance on the learning test indicated that there was no significant difference between the amount of learning that took place ($F=.76$, $p < .38$), but there was a highly significant difference in the amount of transfer ($F=6.83$, $p < .01$). On the transfer test, all three tests resulted in significant disordinal interactions. Two of the disordinal interactions were in the direction of prediction: the PSVR, which was the measure of gestalt visualization, and the NAO, which was the measure of general reasoning ability. The third interaction for PF, which was the measure for analytic ability, was in the opposite direction of prediction. All regression lines were significantly steeper in favor of the T treatment.

5. Interpretations

Treatments can be designed that do teach the same content but which differ in the extent of elaboration. The N treatment does much of the organization for the learner. The N treatment requires less reliance on general reasoning ability, while the T treatment requires more of this ability. The lack of finding different interaction patterns using the analytic and gestalt processing strategies for spatial visualization may mean that the aptitude measures are inappropriate, that the nature of the processing required by the treatments was faulty, or merely that the interactions were all due to general ability (which is the most consistent finding from previous studies).

Abstractor's Comments

This study is very well done and well written. It is a further develop-

ment in the ongoing process of attempting to clarify questions about aptitude treatment interactions. The design is typical of ATI studies in which programmed instruction is utilized to control many of the variables which otherwise might be uncontrollable. The development of the materials follows a careful pattern of preciseness and consistency. The reliability coefficients on the various tests used are quite good for this type of study. In general, the study appears to be very well done and is a contribution to the literature.

There are several items which need to be considered when additional studies are developed in this area:

1. Because of the opposite finding as predicted with the analytic (N) treatment, one might begin to suspect (even more strongly than the writers indicate) that it is in fact general reasoning or general ability that accounts for the interactions in ATI studies. If this is the case then where does one go from here? The secondary purpose of the study (the general reasoning interaction) resulted in the primary finding which has significance for further studies in this area.
2. Because the regression lines are all steeper for the T treatment, does this mean that the T treatment is in fact a better treatment for all students? As the writers note, the Johnson-Neyman technique provided a left boundary for a right region of significance. One should note that the T treatment regression line was always higher in this region of significance than the N treatment.
3. The problem of determining whether or not ATIs exist is one which requires carefully structured treatments, usually with some form of programmed instruction. This limits the generalizability of such findings. Some means around this problem need to be investigated. While this is good basic research and should be continued, it appears it will be a long time before results of this sort will be generalizable.

Fennema, Elizabeth; Wolleat, Patricia L.; Pedro, Joan Daniels; and Becker, Ann DeVaney. INCREASING WOMEN'S PARTICIPATION IN MATHEMATICS: AN INTERVENTION STUDY. Journal for Research in Mathematics Education 12: 3-14; January 1981.

Abstract and comments prepared for I.M.E. by KENNETH E. VOS,
College of St. Catherine.

1. Purpose

The limited enrollment of female students in high school mathematics has an impact on their opportunities for future mathematics-related careers. The purpose of the study was to investigate the effectiveness of a specific intervention program--Multiplying Options and Subtracting Bias. This intervention program was designed to increase the number of mathematics courses selected by a female high school student.

2. Rationale

The intervention program, Multiplying Options and Subtracting Bias, is based on two assumptions:

a) If females' knowledge about sex-related differences in mathematics was increased and certain attitudes toward mathematics were improved, the females' willingness to take mathematics courses would increase; and
b) since females' attitudes are influenced by their social environment, the attitudes toward females as learners of mathematics held by significant others would also need to be changed if females' attitudes were to be changed. (p. 3)

These assumptions and the selection of mathematics courses were explored in this research.

3. Research Design and Procedures

The intervention program for this research report consisted of three 30-minute videotapes, each focusing on a different target audience: student (male and female), counselors, mathematics teachers (male only). The total intervention program includes many other activities, but these activities were not the focus of the evaluation.

A set of nine high schools in urban, suburban, and rural communities in

Wisconsin and Minnesota participated in the project. Within the high schools, students in Algebra I (the majority were ninth graders) and Geometry (the majority were tenth graders) were selected to participate in the study. A pretest-posttest control group design was used. "Schools were randomly assigned to an experimental or control group" (p. 7). Five schools were selected for the experimental treatment (the intervention program) and four schools were designated as the control group.

The dependent variables were self-reports by the students of their plans to study mathematics in high school and after graduation from high school. The independent variables were grouped into two categories--attitudes and cognitive.

Pretesting on all measures occurred in mathematics classes in late spring 1978. The intervention program treatment took place in the fall 1978. Each target audience spent one 40-minute classroom period viewing the appropriate videotape and participating in a brief discussion. Posttest data were collected approximately four weeks after the treatment. The posttest measures included all the pretest instruments.

Means, standard deviations, mean differences, and F ratios for male and female students for all variables were reported. Means, standard deviations, mean differences, and F ratios for counselors and male mathematics teachers for selected variables were reported. A fixed model ANOVA was applied for each variable. In addition, backward stepwise regression analysis was applied "to examine whether the change scores of experimental female students explained the change in their mathematics plans" (p, 8).

4. Findings

A significant difference ($p < .05$) was detected in the amount of change between female students in the experimental and control groups on these variables:

High School Mathematics Plans
After High School Mathematics Plans
Knowledge of Sex-related Differences in Mathematics
Usefulness of Mathematics
Attribution of Success to Ability.

The female students involved in the intervention program "increased their

knowledge about sex-related differences in mathematics and also indicated that they were going to study more mathematics both during and after high school" (p. 11). The enrollment data also indicated that the female enrollment in the experimental schools did increase. The change scores on the measure of Usefulness was the only attitude variable found to be related to the change scores of mathematics plans.

The results of the study reflected significance for male mathematics teachers in the experimental schools on two variables, Knowledge ($p < .05$) and Usefulness-Girl ($p < .10$). The counselors in the experimental schools had a significant difference ($p < .01$) on only one variable, Anxiety-Girl. After viewing the videotape, the counselors perceived more anxiety concerning mathematics in female students.

Male students after viewing the student videotape had an increase in their high school and after high school mathematics plans. They also increased their knowledge about sex-related differences in mathematics. Their stereotyping of mathematics as a male domain was also increased after the intervention program. Male students in the experimental group had decreased scores in the areas of success-effort and perception of their fathers' and mothers' view of their competence in mathematics learning.

5. Interpretations

The intervention program, Multiplying Options and Subtracting Bias, can "substantially influence students' attitudes about mathematics and their willingness to take more mathematics courses" (p. 14).

Abstractor's Comments

This research study touches on a serious problem within the mathematics education community--the lack of female students enrolled in high school mathematics courses. For the last eight years I have been teaching at the third largest women's college in North America. I witness this problem everyday in my office. I frequently see the look of despair on a woman's face when a potential career is shattered due to a deficient background in mathematics; therefore, I sincerely believe the researchers are attempting a possible solution to a tough problem. However, I am disappointed in this research report since there exist a multitude of flaws.

While I witness the problem the researchers are trying to eliminate, I believe the research reported here is not of the quality acceptable in the mathematics education community. The study does offer the opportunity for spin-off studies by other researchers. The basic framework for continuing research is contained in the report and many segments of the project lend itself to further investigations.

I will explain my rationale for stating that this research report is not of the quality acceptable in the mathematics education community by separating the flaws into minor and major flaws.

Minor Flaws

1. Table 2 is an excellent example of the need for a "truth in tables" rule. The table headings "Year 1" and "Year 2" are misleading. They leave the impression of a two-year experiment or two one-year experiments. Actually, the headings refer to the dates of the pre-test (spring 1978) and the posttest (fall 1978).
2. Also in Table 2, an incorrect mean difference was given for the variable Success-Effort (experimental group). It should have read 0.07 rather than -0.06. Within the mean difference columns, there were seven incorrect values given, based on the data listed in the mean columns. A set of standard deviations also was misplaced in the columns.
3. In Table 3 a mean difference of -2.04 was listed for the variable Teacher (experimental group). The correct mean difference according to the data should have read -5.74. Within the mean difference columns, there were thirteen incorrect values given, based on the data listed in the mean columns.
4. The table between Table 4 and Table 6 was not identified with the numeral 5.

Major Flaws

1. According to Table 2, for the variable Anxiety the experimental female subjects decreased in number from 208 to 119, a loss of 89 female subjects. A loss of experimental male subjects was also reported in Table 3 for this variable. Why? No mention was made of this loss in the report. This measure is of some interest in relation to the problem. Did a school refuse to give this specific measure?

2. I am aware that school-based research usually necessitates a minimum amount of classroom disruption; however, an intervention of 40 minutes for the treatment is not an intervention but only a distraction in a mathematics classroom. The short length of exposure to the treatment makes me cast serious doubts on the meaningfulness of the results. Many different and diverse impacts could have occurred in the experimental group between the pretest collection date and the posttest collection date.
3. In my first reading of the research report I detected a design-analysis flaw which almost made me condemn the study on the spot. The experimental unit as determined by the randomization process is schools! Nine schools were randomly assigned to the control or experimental groups; therefore, the degrees of freedom for the F ratio is [1,7] (2 treatments,9 schools) rather than, for example, [1, 382] (Table 2). The analysis of data was performed with the student as the experimental unit. By violating one of the assumptions of the F-statistic, all the results are overly optimistic. I reanalyzed the data with the correct degrees of freedom and the results seem more realistic. This basic flaw--incorrect experimental unit--should have been detected by the reviewers before publication in a respectable research journal.

This research study is attacking a definite problem but was so poorly done that its value is suspect. Bluntly stated: good idea-poor execution.

Pigge, Fred L.; Gibney, Thomas C.; and Ginther, John L. TODAY'S ELEMENTARY SCHOOL TEACHERS ARE BETTER PREPARED IN MATHEMATICS. Arithmetic Teacher 26: 48-51; March 1979.

Abstract and comments prepared for I.M.E. by JOHN A. DOSSEY,
Illinois State University.

1. Purpose

The purposes of this study were to assay the mathematical understandings of a group of preservice and in-service teachers of elementary school mathematics and to compare these results with the outcomes from an earlier study conducted by the authors (Gibney, Ginther, & Pigge, 1970).

2. Rationale

Given the decline in the school-aged populations's abilities to deal with mathematical concepts and skills, the authors felt that a similar assessment needed to be made of the mathematical understandings of preservice and in-service teachers of elementary school mathematics. In addition, they were interested in seeing if the superior performances of preservice teachers in the 1967-69 study would still occur.

3. Research Design and Procedures

A sixty-five item multiple choice mathematics test was used in both the 1967-69 study and this 1975-77 replication. The test contained items grouped to give the following seven subtest scores: geometry, number theory, numeration systems, fractions, structural properties, sets, and operations. In 1967-69, the test was given to 887 preservice teachers and 177 in-service teachers. The 1975-77 study saw the collection of similar data from 761 preservice teachers and 176 in-service teachers. In both cases these teachers were students enrolled in mathematics education courses at Bowling Green State University (n_i the ratio of 2:2:1).

The test scores for both the preservice and in-service teachers were then analyzed for differences with respect to the time period (1967-69), level of experience differences (preservice versus in-service), length of experience (preservice, 0-2 years, 3-5 years, 6-10 years, 10+ years), and by grade level of teaching interest (K, 1-3, 3-4, 4-6, or 7-8).

4. Findings

The first analysis reported compared the performance of preservice and in-service teachers in each of the two testing periods. In both the 1967-69 and 1975-77 testing periods the preservice teachers performed better than their in-service counterparts. In both administrations, the preservice teachers had higher means on both the total test and each subtest. In the 1967-69 time frame, the preservice teachers did significantly better in the areas of geometry, number theory, structural properties, sets, and on the total test. In 1975-77, the preservice teachers performed significantly higher in the areas of geometry, number theory, numeration systems, structural properties, sets, and on the total test.

The second data analysis compared the preservice teachers' performances and the in-service teachers' performances across the two administrations of the test. The comparison of the performance of the preservice teachers in 1967-69 with the preservice scores in 1975-77 showed that the 1975-77 preservice teachers had higher means in each area except fractional numbers. In each case the differences noted were judged significant. For the in-service teachers much the same pattern repeated, with the 1975-77 group of teachers having higher means for each of the subtest areas except fractional numbers. In each of the cases, the differences noted were judged significant, except in the area of sets, where the difference of means favored the 1975-77 teachers, but not significantly. It is especially interesting to note that the 1967-69 teachers at both the in-service and preservice levels scored significantly higher than their respective counterparts in the 1975-77 time period.

The next analysis reported dealt with the preservice and in-service teachers' performances when they were classified by years of experience. The categories of experience were: preservice, 0-2 years, 3-5 years, 6-10 years, and 10+ years. This analysis showed that the preservice teachers in each time frame, 1967-69 and 1975-77, scored higher than any of the experience groups. Each of these differences was judged statistically significant. No differences were found between the groups of experienced in-service teachers.

The final analysis compared the performances of preservice and in-service teachers with their counterparts and with each other across the eight-year time interval. For this analysis the teachers were grouped by the grade level

of greatest interest or current teaching (K, 1-3, 3-4, 5-6, or 7-8). The analysis of the 1967-69 data showed that the preservice teachers preparing for grades 1-2 and 3-4 scored significantly higher than their experienced counterparts. In the 1975-77 phase of the study, the preservice teachers scored higher than their experienced counterparts at the K, 1-2, and 3-4 grade levels. When the preservice teachers were compared with one another over the 1967-69 to 1975-77 time period, the data showed that the 1975-77 teachers scored higher at all levels except for the kindergarten level. These differences were significant for the 1-2, 3-4, and 5-6 grade levels. For in-service teachers, the 1975-77 teachers scored higher on all levels except kindergarten than the 1967-69 teachers. The differences noted at the 1-2 and 3-4 grade levels were judged to be significant statistically. Again, the 1967-69 kindergarten teachers scored higher, but not significantly.

5. Interpretations

The authors make few interpretations based on the data summarized above. They note the overall improvement of the 1975-77 teacher group over the 1967-69 teacher group and use this to justify the title of the article. They further note the consistent difference in scores between the preservice teachers and the in-service teachers. They use this difference to question whether different mathematical and mathematical education programs might be offered for preservice and in-service teachers. A final point of concern was expressed about the decline in performance of the kindergarten teachers from 1967-69 to 1975-77. While this difference was determined with a small n, the trend was felt to be indicative of the mathematical understandings of early childhood majors and teachers.

Abstractor's Comments

The results of the above study confirm the findings of other studies about the increased mathematical training of elementary majors (Dossey, in press). The results by grade level and experience level add data not found in other sources about the mathematical training of elementary majors and teachers. In addition, the question about the separation of preservice and in-service programs because of the mathematical needs of the individuals involved deserves further study.

Many of the points which could be considered in such a study either were not, or were not reported. Several aspects of the study needed better reporting, among them:

1. No apparent changes were made in the study or the reporting of the study since the original article in 1970, even though several suggestions were made in an I.M.E. review (Reys, 1972).
2. No description was given of the mathematical backgrounds of the preservice and in-service teachers across the two time frames sampled. Had the teachers in the 1975-77 had more secondary school mathematics? Were they products of "modern" programs?
3. No information was given on the method used to obtain students to take the tests upon which the analyses were performed. Were they general elementary majors or were some of them mathematics specialists?
4. No information was given on the test itself. The data reported in the original Arithmetic Teacher article indicated that the reliability was quite low (.80) and no information was given on the reliability of the subtests. Further, concerns would have to be expressed about the validity of the items across the eight-year span between the two administrations of the test. The mathematics preparation of elementary teachers is quite different today than it was in 1967-69.
5. While the authors speak of differences in the mathematical preparation and needs of the preservice and in-service teachers, they do little to document what might be done differently to react to these apparent differences.

These and other added information would increase the applicability of the results to the improvement of teacher education programs for both preservice and in-service teachers. Such research is needed to add to the post-CUPM period of improvement of teacher education for elementary school mathematics.

References

Dossey, John A. The current status of preservice elementary teacher education programs. Arithmetic Teacher, (in press).

Gibney, T. C., Ginther, J. L., & Pigge, F. L. The mathematical understandings of preservice and inservice teachers. Arithmetic Teacher, 1970, 17, 155-162.

Reys, R. E. Expanded abstract and analysis of "The mathematical understandings of preservice and in-service teachers." Investigations in Mathematics Education, 1972, 5, No. 2, 13-16.

Sherman, Julia. MATHEMATICS, SPATIAL VISUALIZATION AND RELATED FACTORS: CHANGES IN GIRLS AND BOYS, GRADES 8-11. Journal of Educational Psychology 72: 467-482; August 1980.

Abstract and comments prepared for I.M.E. by LINDA R. JENSEN, Temple University.

1. Purpose

The purpose of the study was to determine if "sex-related differences in mathematics performance in grade 8-11 developed as a function of sex-related differences in spatial visualization and sociocultural influences that consider math to be a male domain."

2. Rationale

Earlier studies by Sherman, Fennema, and others have shown the relationship of spatial visualization to mathematics performance and achievement in science, engineering, and chemistry. Spatial visualization has been shown to differentiate girls taking more or less high school mathematics, and spatial visualization and mathematics performance have been thought to show the largest differences of all the cognitive skills in favor of males from adolescence through adulthood. Research was needed to show if either spatial visualization or sociocultural attitudes could be shown to be causal factors for mathematics achievement.

3. Research Design and Procedures

Subjects were selected from a group previously tested in 1976 during the spring semester of Grade 8. In 1978-79 when the students were in Grade 11 an attempt was made to locate and retest the students. Approximately one-half of the girls (135 of 260) and one-third of the boys (75 of 223) became part of the final sample. The final sample differed from the original group only in one aspect: the boys had significantly higher vocabulary scores. Boys and girls both were nearly one standard deviation above the norm in Spatial Relations and Basic Mathematics Concepts.

In Grade 8, students were tested on the Cognitive Abilities Test Verbal Battery; the Space Relations Test of the Differential Aptitude Test; the Mathematical Concepts Test; the Romberg-Wearne Problem-Solving Test; and the

eight sections of the Fennema-Sherman Mathematics Attitudes Scales II. Tests used in Grade 11 were the same except for the mathematics concepts and problem solving scales, which were changed to the Basic Mathematics Concepts Test and the Mental Arithmetic Problems (Form AA).

Grade 11 mathematics performance and the Confidence in Learning Mathematics Scale were predicted by mutliple regression. Regressions were done for males, females, and both sexes combined, with an examination of differences between the sexes. Change in attitudes toward mathematics was analyzed by multiple analysis of variance.

4. Findings

No sex differences were found in Grade 8 or 11, or for spatial visualization, the number of college preparatory mathematics courses, or mathematics-related courses taken in Grade 8. There were no significant differences between the sexes on mathematical problem solving or mathematical concepts. However, in Grade 11 boys outperformed girls in these areas.

Large significant correlations (.45 to .79) were found between vocabulary, spatial visualization, years of mathematics, mathematics concepts, and problem solving as measured in Grade 8 and mathematics performance in Grade 11. For girls, 15 of 16 correlations between attitudes and mathematics performance were significant at the .05 level, but this was true for only 3 of 16 correlations for boys. Sexes differed at the .01 level in correlations between Math as a Male Domain and both measures of mathematics performance.

Multiple correlations predicting mathematics concept knowledge and problem solving were > .80. The multiple correlations predicting Confidence in Learning Mathematics were > .65. For females, vocabulary had the heaviest weight (-.31).

Female attitudes toward mathematics declined on four scales and improved on two, while male attitudes declined on one scale and improved on two.

5. Interpretations

"Since the presence or absence of a sex-related difference covaried with the presence or absence of more favorable attitudes toward mathematics among males, it was concluded that the source of the difference could be attributed to sex-related differences in the attitudinal facors." Because attitudes

toward mathematics, and not spatial abilities, changed differentially for the sexes, attitudes were considered to have a stronger effect on abilities in problem solving and mathematics concepts.

Specifically, female perception of mathematics as a male domain "emerged as an important causal variable" because it was the only variable for either sex in which the relationship between attitude in Grade 8 and mathematics performance in Grade 11 was higher than the correlation between performance in Grade 8 and attitude in Grade 11.

Abstractor's Comments

Sherman is to be commended for her work over the past fifteen years, which has added greatly to the body of knowledge concerning the importance of sex-related differences in mathematics. The current study is noteworthy because it follows a large group of students for three years and compares test results in three areas of previously shown sex differences: mathematics performance, attitudes toward mathematics, and spatial visualization.

Some problems in the sample should be noted. While one-half of the girls from the original sample took part in this study, only one-third of the boys did so. This may have skewed the test results. This may be especially true since the eleventh-grade boys were shown to be significantly higher in vocabulary than the eighth-grade boys, and vocabulary for girls had a significant negative correlation with confidence in learning mathematics.

The fact that the sample was nearly one standard deviation above the national norm on both spatial relations and mathematics concepts makes generalization of the results difficult. The author rightly notes the problems with changing both the mathematics concepts and the problem solving instruments from those used in eighth grade to those used in eleventh grade.

Looking at cross-lagged correlations to determine a causal variable is an interesting technique, but should be carefully examined. In this instance, there were 16 sets of correlations between attitudes and performance for each sex. Of these 32 sets of correlations, only the correlations between Math as a Male Domain and problem solving, and Math as a Male Domain and mathematics concepts for females, were significantly higher between eighth-grade attitude and eleventh-grade performance than between eighth-grade performance and eleventh-grade attitude. Because Math as a Male Domain had the lowest

split-half reliability of the eight attitude scales (.69) and both concept and problem-solving scales were different in Grade 8 and Grade 11, claiming that the female perception of mathematics as a male domain was a causal factor in mathematics performance seems suspect.

I agree with the author when she states that "The present data add to an accumulated picture stressing the importance of sex-role factors in the development of sex-related differences in mathematics performance. Findings, however, are fundamentally correlational, and verification is needed through experimental methods."

I would like to see investigations in this area use information from research on brain functioning such as that studied by Davidson and Wheatley, and information on aptitude-treatment interaction such as that studied by Carry et al. Combining research in the three areas of sex-related differences, brain functioning, and aptitude-treatment interaction might be a powerful tool in our search to improve the knowledge base and teaching methods in mathematics education.

Smith, Susan R.; Szabo, Michael; and Trueblood, Cecil R. MODES OF INSTRUCTION FOR TEACHING LINEAR MEASUREMENT SKILLS. Journal of Educational Research 73: 151-154; January/February 1980.

Abstract and comments prepared for I.M.E. by ROBERT M. TODD* and RICHARD T. GRAHAM, Virginia Polytechnic Institute and State University.

1. Purpose

To test the effectiveness of three methods (abstract, graphic, or manipulative) of teacher presentation on manipulative measurement skills using linear measurement tasks.

2. Rationale

> Bruner ... attempted to develop an instructional theory ... He asserted that children learn by proceeding through three progressively more abstract modes:
>
> 1. Use of manipulative action with the objects (enactive mode)
> 2. Use of graphic materials to represent the objects (graphic mode)
> 3. Use of abstract symbols to represent the actions performed with the objects (symbolic mode). (p. 151)

Szabo and Trueblood expanded on Bruner's modes by including not only the student output modes but also the instructor input mode, producing a (3 x 3) matrix.

Student Output Modes for Responding to Metric Measurement Tasks	Teacher Input Modes for Presenting Metric Measurement Tasks		
	M	G	A
M (Manipulative)	M,M	G,M	A,M
G (Graphic)	M,G	G,G	A,G
A (Abstract)	M,A	G,A	A,A

Figure 1. Matrix of Instructional Modes for Teaching Metric Measurement (p. 151)

*On leave 1980-81 while serving as Associate Professor in the College of Allied Medical Sciences of University of Riyadh, Saudi Arabia.

Two expectations were stated:

1. Students given manipulative instructional input (M,M) will achieve higher scores on linear measurement posttests than students given graphic instructional input (G,M).

2. Students given manipulative instructional input (M,M) will achieve higher scores on linear measurement posttests than students given abstract instructional input (A,M). (pp. 151-152)

3. Research Design and Procedures

Sixty-six first- and second-grade children were randomly assigned to three treatment groups in such a way that the groups had an equal number of conservers and nonconservers (of length) as previously tested, using the procedures of Inhelder et al (1974).

The instruction was provided over a three-week period, with the T_1 group getting Abstract mode instruction for four 30-minute daily sessions. The following week T_1 and T_2 groups received Graphic instruction, and in the third week all three groups received Manipulative instruction.

The measurement skills presented to the children each were:

1. relational terms--longer, shorter, same length, as;
2. use of nonstandard units (paper strips, paperclip chains) to compare the height of block towers;
3. use of a small nonstandard unit (paperclip, dowel rod) to iteratively measure the length of an object or picture; and
4. use of cm ruler to measure the length of objects or pictures. (p. 152)

Pupils were posttested at the end of each week's instruction on the four skills listed above. The nine-point manipulative tests differed only slightly in materials used from those used in the instructional phase (that week). Reliability estimates (KR-20) of the three tests were 0.58 (A,M), 0.78 (G,M), and 0.45 (M,M).

4. Findings

Table 1 reports the mean scores for the groups on the first posttests.

Table 1

Weekly Linear Measurement Posttest
Means for Treatment Groups by Week

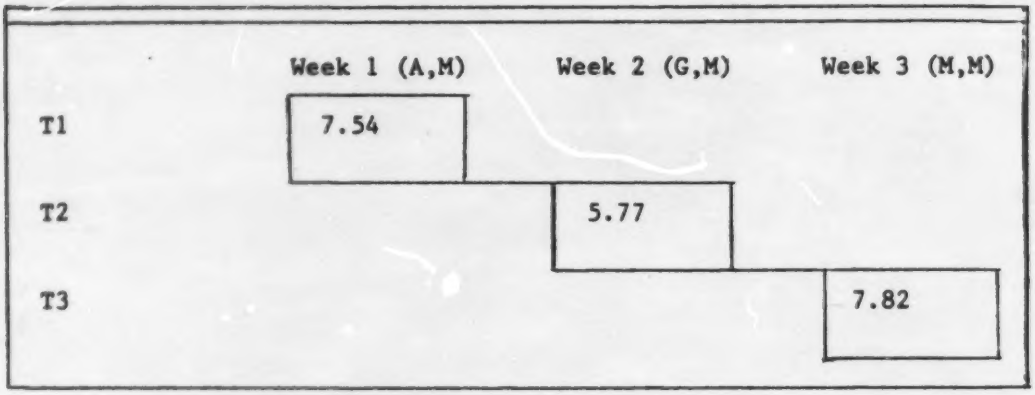

Table 1 presents the mean posttest scores of the treatment groups by week. The data analyzed were the scores of T_1 under (A,M), T_2 under (G,M), and T_3 under (M,M).

An analysis of variance was run on each group's first posttest scores. The data indicate a significant treatment effect ($F = 8.52$, $df = 1/60$, $p < .05$). A t-test between the mean of the Manipulative instructional group and that of the Graphic instructional group was significant ($t = 3.74$, $df = 26$, $p < .05$). Thus, the expectation that manipulative instructional input produces greater acquisition of linear metric measurement skills than graphic instructional input was supported. The group that received manipulative input (teacher demonstrations with materials) scored higher than the group receiving graphic input (use of pictures and charts) when they were required to produce manipulative output.

Another t-test was run to compare the posttest scores of the Manipulative instructional group with the Abstract instructional group. The t-test was not significant ($t = 2.41$, $df = 37$, $p > .05$). Therefore, the second expectation was not supported. The group that received manipulative instructional input did not score higher on posttests of linear measurement than the group that received abstract instructional input (purely verbal) when required to produce manipulative output.

5. Interpretations

> Two conclusions seem to be warranted as a result of this study. First, teacher instruction of a manipulative nature resulted in greater acquisition of linear measurement skills than graphic teacher instruction. Second, no differences were observed between manipulative and abstract teacher instruction using the same criteria. (p. 153)
>
> A question raised at the beginning of this article has still to be investigated. That is, how do children progress from the M,M mode of instruction to the A,A mode? If the goal of educators is to help children develop symbolic ways of thinking and learning, then the question of sequence of instructional modes is an area of research that should be pursued in future studies. (p. 153)

Abstractor's Comments

The reported means of 7.54, 5.77, and 7.82 on a nine-point scale would indicate high performance by at least two of the three groups. The number of length conservers and nonconservers was not reported but would have been interesting to readers. Readers might also be interested in the test means for T_1 and T_2 on the second or third testing on the same skills.

There is apparently an error in the reported t value comparing T_1 and T_3. A t value of 2.41 with 37 degrees of freedom would have a probability of less than .05 rather than greater than .05, s was reported.

Of greater concern than a typographic error is the problem of comparing mean scores on different tests taken by different groups. The tests covered the same skills but had different reliabilities. Were the differences in group means the effect of the treatment or of test difficulty? No evidence was presented to show that the tests were equivalent and that scores were comparable. If the conclusions are to be accepted, we must assume that the test scores could be compared. This we should not do on faith, but only upon evidence. Smith's dissertation may cover the problem in detail. If not, we cannot accept the conclusions as justified by the study.

The methodology of the study illustrates some of the problems in conducting educational research. To avoid the variable of different teachers having different effectiveness, only one teacher is used. Fine, but one teacher may have a preferred teaching mode or be more effective in one mode than another--a teacher-treatment interaction that might have greater effect

than the treatment effect. The other teacher problem in this study is the effect of teaching the same skills more than once in the experiment. Does the teacher become more effective with more practice, less effective through boredom, or is it safe to assume there is no change?

Vaidya, Sheila and Chansky, Norman. COGNITIVE DEVELOPMENT AND COGNITIVE STYLE AS FACTORS IN MATHEMATICAL ACHIEVEMENT. Journal of Educational Psychology 73: 326-330; June 1980.

Abstract and comments prepared for I.M.E. by MICHAEL K. DIRKS and DAVID F. ROBITAILLE, University of British Columbia.

1. Purpose

This dissertation study investigated the relationship between performance on Piagetian cognitive development tasks, cognitive style (and their interaction), and mathematics achievement. The major goal was "to provide a theoretical framework for the learning of mathematics from Piaget's theory about the development of the number concept and Witkin's theory of field dependence-independence."

Specific hypotheses tested were: (1) high-operational children will outperform low-operational children; (2) field independent children will outperform field dependent children; (3) of the four categorized combinations of cognitive operativity and style, high-operational, field independent children will show the highest achievement.

2. Rationale

The researchers cite Piaget (1975) as suggesting "that natural organization of children's mathematical ideas has relevance for mathematics education." Further, several recent studies have found that a significant, positive relationship exists between performance on Piagetian tasks and mathematics achievement among elementary school children. Other researchers have found that field independent children show higher mathematics achievement than their field dependent peers.

This study investigated the dual effects of development level and cognitive style which have been investigated separately, but not simultaneously, in previous studies.

3. Research Design and Procedures

One-hundred two subjects were randomly selected from the second, third, and fourth grades of a suburban Philadelphia school, with 17 males and 17 females selected at each grade level. The appropriate grade level form of

the Stanford Achievement Test (SAT) had been administered to all students in the school that year. The mathematics portion of that test provided the achievement measure for this study.

The Children's Embedded Figure Test (CEFT) was administered individually to measure field independence/dependence. Children whose scores were at or above their grade-median CEFT were classified as field independent; those scoring below, as field dependent.

A Conservation Test Battery was employed to ascertain cognitive development level. This battery was adapted from a series used by Lunzer (1970) incorporating tasks reported by the Genevans. "The testing procedure incorporated a standardized form of administration, although it retained the depth yielded by the clinical interview method of Piaget." Apparently 10 of the 21 tasks reported by Lunzer and relating to conservation of number, seriation, and classification were individually administered. Subjects were classified as high-operational if they succeeded on 7 or more of these tasks including at least 3 of the 5 tasks ranked as most difficult; otherwise, they were classified as low-operational.

4. Findings

Preliminary analysis of the data showed no significant sex differences within any grade level and so this variable was not incorporated in the formal analysis. Statistical results were as follows:

(a) A 2X2 ANOVA (operativity X cognitive style) was performed for each grade level with total SAT raw score as the dependent variable. There was a significant main effect for operativity, favoring the high-operatives, at grade 2 only. Significant main effects were found at all grade levels for cognitive style, favoring the field independent groups. No significant interactions were found at any grade level.

(b) A 2X2 MANOVA (operativity X cognitive style) was performed for each grade level with raw SAT subtest scores (computation, concepts, applications) as the independent variable. As with the preceding analysis, operativity was significant for grade 2 only and for cognitive style at all levels. Univariate F-ratios demonstrated that in the second and fourth grades the significant effect was due to the concepts subtests, while it was due to the computations and applications subtests at the grade 3 level. Again, no interactions were found to be significant.

(c) A 3X2X2 ANOVA (grade level X operativity X cognitive style) was performed with scaled total SAT score as the dependent variable. Scaled scores were used to index developmental trends in achievement. Significant main effects were found for all factors. No interactions were significant. Post-hoc Scheffe procedures revealed a significant progression of means across the three grades. Intra-class correlations for the significant main effects were 0.75 for grade level, 0.11 for cognitive style, and 0.04 for operativity. The cognitive development and cognitive style variables were shown by their low correlations to be unrelated.

5. Interpretations

The abilities involved in high operativity on Piagetian tasks and the disembedding ability required for field independence are both important determiners of mathematics achievement in grade 2. For grades 3 and 4, however, cognitive style is more important than operativity in determining mathematics achievement. The consistent relationship between a field-independent cognitive style and mathematics achievement has "important educational implications." "The importance of gearing instruction to the cognitive style of the learner" is reaffirmed by this study. Previous research suggests that both (1) matching teachers and students according to cognitive style and (2) individualizing instruction according to cognitive style within heterogeneous classes can increase teaching effectiveness. Further research is needed to explore how instruction can be geared to cognitive styles. The developmental implications of the findings are not clear.

Abstractor's Comments

The researchers indicate that their purpose was "to provide a theoretical framework for the learning of mathematics" based on the theories of Piaget and Witkin. While one might agree that they did attempt to test the validity of these two theories simultaneously, there is no doubt that the stated goal had little relationship to the actual study. No theoretical framework was, in fact, provided or established.

The researchers have seriously overstated the educational implications of their study. Much is made of the importance of cognitive style, and of the likely benefits of matching teachers and students on this variable, but

its reported strength is slight compared to that of grade level. Radatz (1979, p. 362) has criticized such matching and noted that results vary with different topics. The authors' second suggestion, regarding individualizing instruction according to cognitive style, should also be accepted cautiously.

Although analysis of variance was used in the data analysis, the paper contains no tabular presentation of the results. The two tables of means which are presented indicate that the authors may not have used weighted means in spite of having unequal cell sizes; in other words, they simply averaged the sample means. One is left to speculate whether they considered using an unbalanced design. Since the information provided was not sufficient to permit verification of the statistical analysis, the results of the study must be treated with some degree of skepticism.

Reference

Radatz, H. Some aspects of individual differences in mathematics instruction. Journal for Research in Mathematics Education, 1979, 10, 359-363.

Webster, Raymond E. VISUAL AND AURAL SHORT-TERM MEMORY CAPACITY DEFICITS IN MATHEMATICS DISABLED STUDENTS. Journal of Educational Research 72: 277-283; May/June 1979.

Abstract and comments prepared for I.M.E. by RANDALL I. CHARLES, Wood County Schools, West Virginia.

1. Purpose

The major purpose of the study was to determine whether students "demonstrating adequate mathematics achievement and those exhibiting performance below expected grade level" (p. 278) differ in short-term memory recall capacity. A second purpose was to determine whether the short-term memory task modality (visual versus aural) was related to student achievement.

2. Rationale

Research and theory suggest that short-term memory capacity has an important influence on learning. Although research in reading and language arts has found that good and poor readers can be differentiated on a variety of short-term memory tasks, there is little research searching for relationships between mathematics achievement and short-term memory capacity. Since "cognitive developmental theories, empirical research, and intervention techniques for mathematics disabled children all confirm a significant relationship between reading and language abilities with arithmetic abilities" (p. 278), there is a need to examine the "role of impaired STM [short-term memory] in mathematics disabilities" (p. 278).

3. Research Design and Procedures

Three groups of sixth graders were selected based on performance on the arithmetic subtest of the Wide Range Achievement Test (WRAT). Ss scoring one to one-and-one-half years below expected grade level were placed in a group callled "mildly mathematics disabled" (N = 24); Ss scoring two years or more below expected grade level were categorized as "severely mathematics disabled" (N = 26). A control group of 23 sixth graders was randomly selected from those who scored at or above expected grade level on the WRAT. Ss in the mildly and severely mathematics disabled groups were apparently not randomly selected.

Each S was individually administered a fixed sequence of 14 strings of seven upper-case consonants and 14 strings of seven digits "randomly interleaved, alternating letter strings with digit strings" (p. 279). One-half of the Ss in each group were administered the 28 strings visually and the others were administered the 28 strings aurally. One week later, Ss were again administered the 28 strings, but in a different modality.

A score for each S was the number of digits and consonants repeated in the correct serial order position. A S's score represented short-term memory capacity, the dependent variable.

Data were analyzed using a 3 x 2 ANCOVA for unequal N's with repeated measures on input modality. Scores on an intelligence test were used as a covariate since a one-way ANOVA indicated a significant difference among the groups. Post hoc analyses using the Tukey b test were conducted.

4. Findings

The ANCOVA revealed significant differences for the main effects of achievement level and input modality. The interaction was not significant. A post hoc analysis showed a significant difference in means for the control group and the severely mathematics disabled group. The other differences for the main effect of achievement level were not significant. Total means and standard deviations for the verbal and aural modalities were not given in the report, and the author does not identify which modality had the greater mean. Post hoc analyses for all ordered pairs of means for the main effect input modality showed that the control group had better recall capacity in the aural condition, while the mathematics disabled students had better recall capacity in the visual mode.

5. Interpretations

The results of the present study support the hypothesis that atypical learners fail to use the same coding mechanisms as efficiently as adequate learners. This inefficiency appears to result in lowered levels of achievement and learning gains (p. 281).

Abstractor's Comments

An examination of the references cited in this article suggests that the

research reported was conducted around 1977. If this date is reasonably accurate, then the research question selected for this study is trite considering the state of the art of research based on information processing models at the time of the study. Of particular interest then and now is not simply do high- and low-achievers process information differently, but rather how do high- and low-achievers process mathematical information and what are the implications for the teaching of mathematics.

The author's review of the literature was dated and narrow, and this no doubt contributed to the selection of the particular research question. Of the 60 references cited, only 13 were related to the teaching and learning of mathematics and, of these, 12 were dated 1970 or before and 7 were at best only remotely related to the research question. Also, the author provided a considerable discussion on research showing significant correlations among short-term memory capacity, intelligence, reading achievement, and mathematics achievement. The author should have at least obtained measures on all of these variables and reported the correlations among them.

Even if the research question examined in this study was significant, there is a flaw in the author's interpretation of the findings. This study is an example of ex post facto research. Althought this in itself is not a problem, the difficulty lies in the fact that the author made an interpretation error not uncommon to ex post facto research. Namely, the author made an unqualified cause-and-effect conclusion from the findings which, although plausible, should only be accepted with great caution. The author should have acknowledged that the design of this study makes a cause-and-effect conclusion tenuous, and that other factors (e.g., reading achievement, poor teaching) may have contributed to the students' low achievement.

There are a number of other points in the design, analysis, and reporting of this study that are disturbing; I'll mention only four. First, total means and standard deviations were not reported for the visual and aural modalities, and it is difficult to interpret the significant main effect. Second, a mean square is omitted in Table 3. Next, calculating all ordered pairs of means for the main effect input modality seems unwarranted for both statistical and interpretation reasons. Last, at least one reference is in error in both the text and reference list (Fraser should be Frayer in Klausmeier, Ghatala, and Frayer, 1974).

Wolleat, Patricia L.; Becker, Ann D.; Pedro, Joan D.; and Fennema, Elizabeth. SEX DIFFERENCES IN HIGH SCHOOL STUDENTS' CAUSAL ATTRIBUTIONS OF PERFORMANCE IN MATHEMATICS. Journal for Research in Mathematics Education 11: 356-366; November 1980.

Abstract and comments prepared for I.M.E. by RUTH ANN MEYER, Western Michigan University.

1. Purpose

The stated purposes of this study were:

(a) to test causal attribution theory in the masculine-typed, content-specific task domain of mathematics.

(b) to examine the effects of level of mathematics achievement, sex and the interaction of level of achievement and sex on attributional patterns.

2. Rationale

Females may avoid mathematics courses because they lack confidence in their ability to learn mathematics, they underestimate their ability to solve mathematical problems, and they do not see mathematics as personally useful. Although these attitudinal variables have been found significantly to influence females' election of mathematics courses, the investigators of this study hypothesized that these variables may interact with yet another factor - the attribution of causation - to produce the "math avoidance" syndrome. More specifically, they hypothesized that if a student attributes successful performance in mathematics to ability, the likelihood of persisting in mathematics is higher than if that success were attributed to an unstable cause such as effort or luck. Conversely, when failure is attributed to ability, lowered persistence will result.

3. Research Design and Procedures

The Mathematics Attribution Scale (MAS) (Fennema, Wolleat, and Pedro, 1979) was administered to 647 female and 577 male secondary students. These students were enrolled in algebra or geometry at one of 10 midwestern high schools. In two schools, the sample included the entire enrollments in algebra and geometry. In the other schools, two or three sections of each

course were selected randomly for inclusion in the study.

The MAS was based on Weiner's attribution model (1974). The instrument contained eight subscales, one for each of the four attribution categories (Ability, Task, Effort, and Luck) paired with both "Success" and "Failure" events. The category of Luck was renamed Environment to be more representative of the wider range of unstable external attributions made by high school students. The mathematics achievement of the sample was measured by either Form A - Algebra or Form A - Geometry from the ETS Cooperative Mathematics Series.

T tests were performed on the mean score of each of the eight MAS subscales to determine whether sex differences in attributional patterns existed. Multiple regression analysis was also used. Each of the attribution measures was regressed on Sex, Achievement, and Achievement X Sex interaction. F tests were used to test the eight multiple regression and the eight partial correlation coefficients.

4. Findings

Females and males differed significantly on the Success - Ability subscale (in favor of males) and the Success - Effort subscale (in favor of females). Significant differences were also found for the Failure - Ability and Failure - Task subscales in favor of females.

The multiple correlation coefficients, ranging from .0849 to .39, were statistically significant for each of the eight MAS subscales. The Sex variable accounted for a significant portion of the Success subscales of Ability, Task, and Effort and of the Failure subscales of Ability and Task. The Achievement variable accounted for a significant amount of the variance for the Success subscales of Ability, Environment, and Task, and for the Failure subscales of Ability, Effort, and Environment. The Sex X Achievement variables explained a significant amount of variance for the Success - Environment and for Failure - Effort subscales.

5. Interpretations

The results of the T tests supported the theory of causal attribution in the masculine-typed, content-specific field of mathematics. The females of the study attributed their success in mathematics to effort, whereas the

males more readily attributed their success to ability. Moreover, females, when explaining mathematics failure, blamed their lack of ability or task difficulty more often than males did.

The multiple regression analyses, with the accompanying regression line graphs, provided further support for the assertion of sex differences in attributional patterns in mathematics performance. The graphs suggested that, although their mathematics achievement may be similar, males and females report different strengths for the causes of their performance.

Abstractor's Comments

This is an interesting study which is an important contribution to the literature of mathematics avoidance. The study was well-conceived. The investigators described clearly their purpose, rationale, research design and procedures, and findings. The statistical analyses are complete and clearly presented. Nevertheless, one must express some skepticism as to the strength of the general conclusions. These concerns arise from such aspects as the variability of the sample, the unit of analysis employed, and the small amount of variance accounted for by the Sex, Achievement, and Sex X Achievement variables in the multiple regression procedures.

There was considerable variability across schools, classrooms, and teachers. The article indicated that the investigators were well aware of this. If the males and females were about evenly distributed among schools and classrooms, then the conclusions of the study may have been little affected by the sample's variability. Female and male distributions for individual schools were not communicated in the article. Since there were 70 more females than males in the study, their school distributions are of added interest.

The performances of the males and females of the study on the MAS subscales were as predicted from causal attribution theory and past research in mathematics avoidance. A follow-up study could be that of determining if the results of this study are consistent with the sample's election of future mathematics courses.

References

Fennema, E.; Wolleat, P.; and Pedro, J. D. Mathematics attribution scale. Journal Supplemental Abstract Service, May 1979.

Weiner, B. Achievement motivation and attribution theory. Morristown, N.J.: General Learning Press, 1974.

Yoshida, Hajime. EFFECTS OF DRILL PRACTICE ON APTITUDE IN THE LEARNING OF MATHEMATICS. Journal of Educational Psychology 72: 706-715; October 1980.

Abstract and comments prepared for I.M.E. by MARKITA G. PRICE,
Stephens College, Columbia, Missouri.

1. Purpose

The purpose was to determine if the results of an earlier experiment by Yoshida could be replicated after the procedure had been revised. The earlier experiment tested the relative efficiency of drill practice in the skill of division.

2. Rationale

Yoshida suggests that "successful drill practice depends on the satisfaction of at least three conditions: (a) the sequencing of subject matter, (b) the aptitude of the learner, and (c) the type of drill practice" (p. 706). Citing research concerning the first condition, Yoshida indicates that division could be broken into seven variables which influence the difficulty of the problem. Thus sequencing of the subject matter in this experiment involved ordering the difficulty level of the problems. Yoshida designed the experiment as an Aptitude-Treatment Interaction study. The ability to do division was defined as the measure of aptitude; the treatment included three types of drill practice. Because the previous experiment resulted in the opposite of the expectations suggested by most ATI studies, the difference was explained by the fact that most ATI studies are concerned with learning a new concept, whereas drill practice students are given concepts they "knew" but have not mastered. Most ATI studies imply that instruction which adapts to the learner is effective. The earlier Yoshida experiment indicated that drill practice instruction which ignores the individual learner showed the greatest gains in test scores.

3. Research Design and Procedures

A 3 x 5 x 5 x 2 mixed factorial (split-plot) design was used. The between-subjects factors were type of drill practice (branching, mixed, fixed) and ability level of each subject (5 levels). The within-subjects factors were difficulty level of the problems (5 levels) and the time of the test

(pre, post). The 135 fourth-grade subjects of three classrooms had learned the division algorithm prior to the experiment. The drill practice lasted five days. The pretest and posttest were identical and consisted of 40 problems at the five difficulty levels. The tests were administered to all students in 40 minutes.

The pretest classified students into five ability levels. A stratified random sample assigned students to the type of drill practice. In branching type of drill practice, students received problems based on their ability level (i,e, ability 1 received difficulty 1). On subsequent days, students received problems based on their past performance. Successful completion of the problems increased the difficulty level on subsequent days. The students in the mixed type of drill received problems at their own ability level for all five days. Students in the fixed type of drill received three problems at each difficulty level regardless of their ability level.

A mixed-factor analysis of variance was done. Following significant F-ratios, a Tukey multiple comparisons test was done on the means of various groups.

4. Findings

There was significant interaction involving ability and difficulty. Students of high ability could solve more difficult problems. A significant interaction also occurred between ability level and time of tests. Lowest ability level students made the greatest gains in test scores. The gains decreased inversely with the ability level. The three-way interaction of drill type by ability level by test was significant. Subjects in ability level 2, fixed type drill, gained the most from pre- to posttest. Lastly, the four-way interaction was also significant. The results replicated the earlier Yoshida experiment.

5. Interpretations

The findings indicate that drill practice was effective and that fixed type of instruction produced the greatest gains from pretest to posttest scores. Since this contradicts results and beliefs of most ATI researchers, Yoshida proposes a consolidation hypothesis to explain these results.

A learner has a certain level of skills upon which to be drilled.

Practicing these skills at a certain difficulty level consolidates the skills at that difficulty level. "Therefore, learners will acquire fewer skills if they are given easy problems (p. 714). Thus the fixed type drill gave each student opportunities in all difficulty levels to improve their skills, whereas the branching type could not guarantee that students would be given problems above their ability level.

Abstractor's Comments

The reviewer had some reservations about some technical aspects of the study. A mixed-factor or split-plot factorial design has some underlying assumptions about population variances and covariances. Did Yoshida determine equality of variances or at least whether constant covariances were present? In addition Tukey's test requires equal n's in each of the cells. Since the n's in the 15 cells (5 ability levels x 3 drill types) were not equal, should the reader assume that a random discarding of data occurred? If not, Scheffe's multiple comparison test should have been used. In any case, it is a more conservative test.

Technicalities aside, the consolidation hypothesis suggested here presents an interesting question to advocates of ATI studies. The hypothesis might be further invesitgated because of the contradictory results this experiment produced. It is hoped that the conclusions of this study will not be applied too literally to other teaching situations. Drill practice is substantially different from concept learning.

An interesting question would be whether this study could be replicated in the United States. If not, perhaps cultural differences in the classroom and in the attitudes of students toward drill practice exercises are confounded in the results obtained.

MATHEMATICS EDUCATION RESEARCH STUDIES REPORTED IN JOURNALS AS INDEXED BY CURRENT INDEX TO JOURNALS IN EDUCATION
January - March 1981

EJ 229 454 Gartland, Michael J. Joint Development of Mathematics and Language Arts Criterion-Referenced Item Pools. Illinois School Research and Development, v16 n3, 99-103; Spring 1980.

EJ 230 299 Trembley, Phillip W.; And Others. Effects of Programming from the WRAT and the PIAT for Students Determined to Have Learning Disabilities in Arithmetic. Journal of Learning Disabilities, v13 n5, 291-93; May 1980.

EJ 230 424 Frank, Alan R.; And Others. Teaching Selected Concepts and Skills in Coin Equivalence and Summation to Handicapped Students. Career Development for Exceptional Individuals, v3 n1, 17-23; Spring 1980.

EJ 230 848 Svenson, Ola; Hedenborg, Maj-Lene. Counting Processes in Simple Addition. Scandinavian Journal of Educational Research, v24 n2, 93-104; 1980.

EJ 230 857 Mebane, Rodney. Academic Computing from a Sharing Point of View. EDUCOM, v15 n2, 2-7, Summer 1980.

EJ 230 908 Carpenter, Thomas P; And Others. Solving Verbal Problems: Results and Implications from National Assessment. Arithmetic Teacher, v28 n1, 8-12; September 1980.

EJ 230 915 Ginsburg, Herbert P. Children's Surprising Knowledge of Arithmetic. Arithmetic Teacher, v28 n1, 42-44; September 1980.

EJ 230 949 Bishop, Alan J. Spatial Abilities and Mathematics Education-A Review. Educational Studies in Mathematics, v11 n3, 257-269; August 1980.

EJ 230 952 Watson, Ivan. Investigating Errors of Beginning Mathematics. Educational Studies in Mathematics, v11 n3, 319-29; August 1980.

EJ 230 953 Noelting, Gerald. The Development of Proportional Reasoning and the Ratio Concept. Part II-Problem-Structure at Successive Stages; Problem-Solving Strategies and the Mechanism of Adaptive Restructuring. Educational Studies in Mathematics, v11 n3, 331-63; August 1980.

EJ 230 959 Elliott, Portia C. Going "Back to Basics" in Mathematics Won't Prove Who's "Right", but Who's "Left" (Brain Duality and Mathematics Learning). International Journal of Mathematical Education in Science and Technology, v11 n2, 213-19; April-June 1980.

EJ 230 961 Harper, Eon. The Boundary Between Arithmetic and Algebra: Conceptual Understanding in Two Language Systems. International Journal of Mathematical Education in Science and Technology, v11 n2, 237-43; April-June 1980.

EJ 230 963 Cohen, Martin P.; Carpenter, John. The Effects of Non-Examples in Geometrical Concept Acquisition. International Journal of Mathematical Education in Science and Technology, v11 n2, 259-63; April-June 1980.

EJ 231 038 Vinner, Shlomo; Shillor, Irith. The Concept of Rule. Mathematics Teacher, n91, 16-18; June 1980.

EJ 231 041 Kiryluk, Stephanie. What the Pupils Think. Mathematics Teaching, n91, 42-44; June 1980.

EJ 231 173 Pereira-Mendoza, L. The Effect of Teaching Heuristics on the Ability of Grade Ten Students to Solve Novel Mathematical Problems. Journal of Educational Research, v73 n3, 139-44; January-February 1980.

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